10/586926
IAP11 Rec'd PCT/PTO 24 JUL 2006
WO 2005/073662 PCT/EP2005/000859

Heat exchanger, in particular a flat pipe evaporator for a motor vehicle air conditioning system

The invention relates to a heat exchanger, in particular a flat pipe evaporator for a motor vehicle air conditioning system, according to the preamble to claim 1.

Previously disclosed in DE 198 26 881 A1 is a heat exchanger, in particular an evaporator, in which a collecting tank made of sheet metal is provided, which is formed from a prepared base plate.

The base plate consists of an aluminum alloy, of which the flat pipes, the corrugated ribs and the lateral component parts as well as the remaining elements of the heat exchanger also consist. It is stamped initially from a plate, which is then formed in such a way that a flat base (essentially a flat collecting tank part) is formed, to the longitudinal edges of which bent component parts (tunnel-shaped collecting tank parts) are attached. The bent component parts are bent to the radius of a cylindrical surface, from which the longitudinal edges are folded in such a way that they lie adjacent to and are parallel to one another and are oriented essentially perpendicularly to the base. The longitudinal edges are provided with a number of brackets arranged distributed over their length, which are inserted through slots in the base and are secured on the outside facing towards the flat pipes. A collecting tank with two chambers, which exhibits relatively high strength, is formed in this way before soldering takes place. The base plate is solder plated or provided with a solder coating.

Provided in the base in each case are raised rim passages, in which the flat pipes are accommodated. The

raised rim passages are pulled tight against the longitudinal edges lying against one another in each case in the area of the longitudinal edges of the base, from which the parts are bent away. This results in a depth for the heat exchanger that is only slightly greater than the sum of the depths of the flat pipes. The longitudinal edges of the parts are provided with slots that are aligned with one another, which are present in the section facing away from the supply side and the return side between the transverse wall and the end of the collecting chambers. The transverse walls are pushed into the chambers from the outside. Slots for this purpose are provided in the parts or in the base.

As the first stage in the manufacture of the collecting tank, a flat base plate is produced, in particular by punching, in which the required brackets and the openings and slots that will subsequently accept these brackets are stamped. The longitudinal edges of the parts are then bent away initially. The raised rim passages are then incorporated. If the separating walls will be introduced from the base into the chambers, the raised rim passage-like slots for the separating walls are also provided as part of the same operation in conjunction with producing the raised rim passages. If the separating walls will be pushed into the chambers from the side, the necessary slots are already incorporated in the flat base plate. After producing the raised rim passages, bending of the collecting tank continues until it is complete. The brackets are then secured.

Before soldering the heat exchanger provided with the flat pipes and the corrugated ribs and the lateral component parts, the front sides of the collecting tanks are closed by means of an inserted cover. The covers are manufactured as a pressed sheet metal component, which exhibits an embossed edge

corresponding to the contour of the front sides of the collecting tanks. One of the covers in this case exhibits openings for the connection of the cooling medium supply and return lines. The edge is provided with transverse embossing in the area of the longitudinal edges, which is adapted to the sum of the wall thicknesses of the longitudinal edges. The presence of the embossed edge produces a step, which is positioned against the internal walls of the collecting tank when the covers are applied and forms a joint that is secured by friction. This joint that is secured by friction is supported by means of several brackets, which are attached to the embossed edge and are bent through 90°. These brackets engage around the collecting tanks on the outside.

In addition to this, previously disclosed evaporators exhibit ribs that are oriented essentially parallel, in the case of the standard, customary rib densities (including for small rib heights), and a small opening angle between the individual ribs, which exhibit unfavorable water storage tendency due to capillary effects, that is to say they are able to store a lot of water locally due to the given geometry.

In the event of poor water drainage, the evaporators exhibit a tendency under certain circumstances to spray water - above all in the case of a large volume of air and small front sides - which in turn limits the acceptable rib density (number of rib sections per unit of length in the longitudinal direction of the pipes). The risk of spraying increases as the amount of condensate that collects in the individual rib coils increases and as the area through which the air can flow freely decreases.

Evaporators with almost parallel ribs and small opening angles between the individual rib sections, for example, exhibit an unfavorable water storage and

drainage performance on the basis of the given rib geometry. In particular, the rate of flow and the air volume are then limited to a point at which spraying is still avoidable.

The object of the invention is to make available an improved heat exchanger. One object in particular is to achieve improved water separation and/or a reduction in the water storage capacity.

This object is achieved by a heat exchanger having the characterizing features of claim 1 or claim 13. Advantageous embodiments are the subject of the dependent claims.

Proposed in accordance with the invention is a heat exchanger comprising at least one collecting tank made of sheet metal, which is divided in the longitudinal direction into at least two chambers, and the ends of pipes, in particular flat pipes, are introduced in the base thereof, which collecting tank exhibits a tunnel-shaped collecting tank part, an essentially flat collecting tank part, which forms the base, and covers which are arranged in each case on the front side, characterized in that at least one cover is embodied in a flat manner, at least in the area of its outer edge, and is positioned in the collecting tank with a positive fit. The flat execution of the cover permits the simple manufacture of the same by stamping from a metal sheet and simple fitting. The covers take up less space compared with the customary, deep-drawn covers, so that the heat exchanger has smaller overall dimensions. In fact, a metal sheet which corresponds, at least in its essential respects, to the metal sheets used in the separating wall can be used for the closed front sides of the heat exchangers. The ability to achieve positioning with a positive fit in the collecting tank ensures optimal soldering.

The cover is preferably introduced from the front side, in conjunction with which on the collecting tank side it lies against a number of stops that are formed on the tunnel-shaped part of the collecting tank and/or on the flat part of the collecting tank. On the outside, the cover is preferably secured by means of a number of bent brackets, which brackets lie at a distance from the stops such that the cover is accommodated between them with the least possible free play. The brackets can be bent about an axis running parallel to the longitudinal axis of the collecting tank. Alternatively, they can be bent from the outside inwards. In order to ensure secure soldering, the cover, at least in the area in the vicinity of the collecting tank, exhibits a thickness in the order of 1 to 2 mm, and preferably 1.5 mm. The positioning with a positive fit before soldering results in improved tightness of the cover. The reliability of the process can be increased in addition, so that fewer defective heat exchangers are produced.

The brackets are preferably a part of the tunnel-shaped part of the collecting tank and/or the flat part of the collecting tank, in conjunction with which they are executed by stamped slots in the base plate forming the corresponding part of the collecting tank and in a single piece with it.

The cover in the case of the supply and return of the cooling medium on the front side preferably exhibits an opening, the edge of which is bent outwards, in particular in the form of a raised rim passage, in conjunction with which a different embodiment of the opening, in particular an oval embodiment, is possible, so that the surface of the cover can be utilized to an optimal extent with a maximum flow surface.

The opening is preferably of conical execution, in particular with an angle between the edge and the

longitudinal axis of the raised rim passage having a maximum value of 5°, and in particular preferably from 2° to 3°, so that self-locking is assured.

A suction pipe is preferably provided, which is attached to the cover with an opening and exhibits an internal diameter that corresponds more or less to the external diameter of the edge circumscribing the opening, in conjunction with which the suction pipe is pushed over the raised rim passage. This permits a constant flow cross section, which expands slightly in the direction of flow, so that this is executed as large as possible and the pressure drop on the coolant side can be kept as low as possible. The efficiency of the evaporator can be increased in this way.

An injection pipe, which is attached to the cover with an opening, preferably exhibits an external diameter that corresponds more or less to the smallest internal diameter of the edge circumscribing the opening.

To facilitate the introduction of the cover, the edge of the collecting tank sheet for the cover preferably exhibits an insertion taper, which can be executed as a bevel or can also be of rounded form.

The two tunnel-shaped parts of the collecting tank preferably exhibit an essentially semicircular form, and thus have a positive effect on the physical properties of the collecting tank, so that the material thickness - compared with that of conventional collecting tanks - can preferably be reduced, in particular to wall thicknesses in the order of 0.8 mm in the event of the attachment of an injection pipe and a section pipe from the direction of one of the front sides (through two covers), or in the event of the attachment of the same on the longitudinal side via an attachment projection in the order of 1 mm in the area of the collecting tank. The reduction in the thickness

of the sheet results in a saving of material and weight, so that the manufacturing costs and the subsequent operating costs can be reduced.

The flat pipes that are used preferably exhibit a width of 2 to 3 mm, as a consequence of which they are of narrower execution than conventional flat pipes.

The heat exchanger is able to accommodate a four-fold or greater flow, and in particular a six-fold flow, depending on the block width.

According to a further aspect of the present invention, a heat exchanger exhibits flat pipes and corrugated ribs, in conjunction with which the corrugated ribs exhibit a rib height which corresponds in each case to the distance between two flat pipes, and in conjunction with which two rib sections connected in each case via a rib arc are inclined towards each other at an opening angle α. For a rib height of 3 to 6 mm, and preferably 4 to 5 mm, and a rib density of 50 to 90 ribs, and preferably 60 to 80 ribs, and in particular preferably 70 ribs per 100 mm, a larger angle between the individual ribs (for an identical rib density and identical radius of curvature) is obtained in accordance with the present invention. Thanks to this greater opening angle of the ribs, a smaller capillary effect is achieved in the rib coils, which leads to a better condensation water drainage behavior and a smaller quantity of water stored locally in the rib coils, and accordingly also in the evaporator, and, where appropriate, also reduces the risk of spraying by the evaporator. The opening angle of at least two rib sections, and preferably a large number or all of the rib sections, preferably amounts to 22° +/- 7° or 30° +/- 10° in this case.

A further increase in the opening angle is achievable under certain circumstances, if one or more rib arcs

exhibit a radius of curvature smaller than 0.4 mm, at least in some areas, and preferably smaller than or equal to 0.35 mm, and in particular preferably smaller than or equal to 0.3 mm. A width of the flat pipes in the order of 1.5 to 3 mm is advantageous in this case.

The use of a smaller rib height and a larger rib opening angle on the one hand reduces any capillary effect in the rib coils, so that less condensate remains in the rib coils. A smaller quantity of water that is capable of being stored and, under certain circumstances, improved water drainage and, where appropriate, a reduced risk of spraying are also associated with this. On the other hand, a smaller rib height leads to the distribution of the condensate over more ribs and pipes (greater heat exchange surface area), so that a smaller amount of condensate in total is produced per rib coil. This in turn results in a reduced risk of spraying and, under certain circumstances, a more favorable drainage behavior along the pipes and/or the ribs.

Possible indirect advantages include a higher permissible rib density and an associated increased performance potential, a lower risk of bacterial growth and associated reduced odor generation and, where appropriate, a saving in cost as a result of simpler surface treatment, which may even be omitted entirely under certain circumstances. In addition, a reduction in the so-called flash fog risk (sudden misting of windscreens caused by moisture from the evaporator) is possible by more rapid drying of the surface of the evaporator.

A heat exchanger of this kind is used in particular as a flat pipe evaporator for a motor vehicle air conditioning system.

The invention is explained in greater detail below on

the basis of an illustrative embodiment and with reference to the accompanying drawing.

In the drawing,

Fig. 1 shows a perspective representation of a collecting tank,

Fig. 2 shows a detailed view of the collecting tank in Fig. 1,

Fig. 3 shows the collecting tank in Fig. 1 before installation of the cover applied from the front side,

Fig. 4 shows a detailed view of Fig. 3,

Fig. 5 shows a detailed view of the collecting tank in Fig. 1, where the right-hand one of the two covers is not represented,

Fig. 6 shows a detailed view corresponding to Fig. 5 from a different perspective,

Fig. 7 shows a side view of the cover,

Fig. 8 shows a section along line A-A in Fig. 7,

Fig. 9 shows a sectioned representation corresponding to Fig. 8 without a cover,

Fig. 10 shows a section through both covers with the suction pipe and the injection pipe assembled,

Fig. 11 shows a section in the longitudinal direction of the collecting tank for the representation of a separating wall,

Figs. 12a, 12b show views of two corrugated rib sheets, where a previously disclosed form is represented in Fig. 12a, and a form for a larger pipe density is represented in Fig. 12b,

Figs. 13a, 13b in each case show a section through a corrugated rib of an evaporator with various geometries,

Fig. 14 shows the stored quantity of water as a function of the heat exchange surface,

Fig. 15 shows the stored quantity of water depending on the rib height (in operation at a set operating point and for identical heat exchange surfaces), and

Fig. 16 shows the critical air quantity in respect of the spraying of an evaporator depending on the rib height.

A flat pipe evaporator 1 (represented only partially) for a motor vehicle air conditioning system exhibits, as already described above with reference to DE 198 26 881 A1, two collecting tanks 2, flat pipes (not represented here), which run between the two collecting tanks 2, and corrugated ribs 3, which are arranged between the flat pipes. Every collecting tank 2 is formed in accordance with the illustrative embodiment from a base plate, which is stamped from a metal sheet and is then formed in such a way that a flat collecting tank part 4 and two tunnel-shaped collecting tank parts 5 connected to its longitudinal edges are formed (see in particular Figures 4 and 6). The longitudinal edges are provided with a number of brackets arranged distributed over their length, which are inserted through slots in the flat collecting tank part 4 and are secured on the outside facing towards the flat

pipes. The front ends are closed by means of covers 6 described at a later point.

Formed in the flat collecting tank part 4 are a number of raised rim passages 7, into which the flat pipes are introduced, in conjunction with which the opening for the raised rim passages 7 corresponds to the outer form of the flat pipes in essential respects.

Because of their relatively low overall depth, the two tunnel-shaped collecting tank parts 5 exhibit an essentially semicircular form, as can be appreciated from the representation in Fig. 7, for example. Because of the improved strength characteristics as a consequence of the semicircular form of the collecting tank parts 5 and/or the smaller overall depth, wall thicknesses of 0.8 to 1 mm are possible by comparison with the customary wall thicknesses of 1.2 to 1.5 mm.

Provided on the inside of the collecting tank 2 are one or more separating walls 8, by which the flow path for a fluid, such as the cooling medium through the heat exchanger, and in particular its flat pipes, can be determined. The separating walls 8 are capable of being introduced through slots 9, preferably in a flat collecting tank part 4, which separating walls 8 are arranged in each case between two openings or raised rim passages 7 for the pipes, such as flat pipes, and the distance between the raised rim passages 7 is preferably not changed by the separating walls 8. A separating wall slot for this purpose is stamped or applied in some other way, for example in one area of the collecting tank 2, so that under certain circumstances no raised rim passage is formed, and/or a guide element, such as a guide groove, for example with a depth of 0.2 to 0.3 mm, is provided as a guide for the separating wall 8 in another area (see Fig. 11).

The covers 6 consisting of a metal sheet are attached to the collecting tank 2 from the front side, in conjunction with which they are introduced as far as stops 10 formed by stop abutments, which are formed on the base plate by means of embossing and are locked in position by means of brackets 11 stamped during manufacture of the base plate and bent over after positioning of the cover 6. To permit the easier introduction of the covers 6, insertion tapers are provided on the base plate (see the phase passing over about half of the thickness of the base plate in Fig. 9). Both the brackets 11 and the stops 10 in the tunnel-shaped collecting tank part 5 are present in the longitudinal direction of the collecting tank 2 viewed at the same height in each case. According to the present illustrative embodiment, only one stop 10 and two brackets 11 offset in relation to it are provided for each cover 6 in the flat collecting tank part 4, although according to a variant not represented in the drawing, an arrangement corresponding to the tunnel-shaped collecting tank part 5 is also possible. The brackets 11 are separated from one another by the stops 10 viewed in the longitudinal direction of the collecting tank 2 by the thickness of the sheet metal forming the cover 6, so that exact positioning is possible as a result of a positive-fit connection before soldering.

According to the present illustrative embodiment, the brackets 11 are bent about an axis which runs parallel to the longitudinal axis of the collecting tank. According to a variant that is not represented in the drawing, bending of the brackets towards the cover is also possible, so that only two slots per bracket running in the longitudinal direction of the collecting tank require to be provided in the base plate. Moreover, according to a further variant that is not represented in the drawing, the extent to which the covers are pushed in can be restricted in each case by

the first raised rim passage for the flat pipes, so that stops now only need to be provided in the tunnel-shaped collecting tank part, and the overall length of the collecting tank can be utilized to an optimal degree.

The supply and return of the cooling medium takes place, as can be appreciated from Fig. 10, respectively via an injection pipe 13 and a suction pipe 14 attached to a cover 6 provided with an opening 12. The openings 9 in the covers 6 are executed as raised rim passages in the corresponding stamped metal sheet, in conjunction with which the covers 6 are installed in the collecting tank 2 in such a way that the edges of the raised rim passage project outwards in each case. The starting thickness of the sheet metal for the cover 6, i.e. the thickness of the unworked sheet metal, is in the order of 1.5 mm, in order to ensure a secure soldered connection to the narrow sides and an adequate material thickness for the raised rim passages, so that an adequately large connecting surface and thus a secure connection between the pipes can also be assured for the supply and return of the cooling medium and the raised rim passages. In this case, too, the covers 6 can also be executed without raised rim passages, at least in their outer peripheral areas next to the base plate of the collecting tank 2.

The raised rim passage for the injection pipe 13 is embodied in such a way that the injection pipe 13 is pushed into the opening 12 as far as the stops 10. For this purpose, the raised rim passage for the cover 6 exhibits a slightly conical, outwardly decreasing internal diameter over the length of the raised rim passage. The raised rim passage for the suction pipe 14 exhibits an outwardly decreasing external diameter, in conjunction with which the suction pipe 14, which is flared slightly at its end, is pushed on from the outside. The taper in the case of both openings 12

preferably amounts to 2-3°, although it does not exceed 5°.

Five-chamber flat pipes, in particular with a width in the order of 2.5 mm, are preferably used, in conjunction with which the step distance remains unchanged, so that the pressure drop on the air side is increased not at all or only insignificantly compared with previously disclosed evaporators with a normal overall depth. The flow through the evaporator can take place as a six-fold flow, for example, or particularly in the case of small block widths, as a four-fold flow.

In Fig. 13, the rib geometry (opening angle α between neighboring rib sections 101, which are attached to one another via a rib arc 102) is represented comparatively respectively for an 8 mm (Fig. 13a) and a 4.5 mm rib height (Fig. 13b), in each case with 60 ribs per 100 mm. In Fig. 13b, a rib arc 102 is shown with a smaller radius of curvature (compared with Fig. 13a). Reference should be made in this respect to the fact that a radius of curvature can differ at each point on the rib arc 102, and that accordingly, apart from a cross section in the form of the arc of a circle, other symmetrical or asymmetrical forms of the rib arc 102 are also possible.

For an overall depth of T = 40 mm, for example, ribs with a rib height h = 4.5 mm can be used on the one hand, whereby a large number of ribs and flat pipes and a higher rib efficiency and a greater heat exchange surface can be achieved for an identical size of evaporator. A higher performance density is achieved in this way.

Fig. 14 depicts the stored quantities of water as a function of the heat exchange surface of tested heat exchangers, in conjunction with which rib height 1 is greater than rib height 2, and rib height 2 is greater

than rib height 3. A positive influence of the smaller rib height on the storage capacity is noticeable in this case, too. These values were arrived at by means of a simple screening test, in which the evaporator is first immersed in a water bath and, after being removed and after a specific dripping period has elapsed, any residual quantity of water that is still present in the evaporator is determined by weighing.

In Fig. 15, the stored quantities of water in relation to the heat exchange surface are represented with reference to the rib height, where the rib height decreases towards the right. The values were determined under operating conditions at a given operating point.

In Fig. 16, the critical quantities of air are plotted in relation to the rib height from which spraying of the evaporator commences in each case (values similarly determined under operating conditions). The rib height here increases towards the right.

In the case of evaporators according to the state of the art, the opening angle α is in the order of 14° (for 60 ribs per 100 mm) or lower. With the new rib geometry (H = 4.5 mm, T = 40 mm), angles in the order of 28° can be achieved (again for 60 ribs per 100 mm) (see also Fig. 13). The opening angle can be further increased in the case of an even smaller execution of the radiuses of curvature of the rib arcs 102.

Given the improved function against spraying, higher rib densities are also possible, and these in turn have a positive effect on the performance, even though the opening angle is slightly reduced once more. In one preferred illustrative embodiment, a 4.5 mm high rib with a rib density of >= 70 ribs per 100 mm is used, in which case the opening angle is then in the order of 22°.

The resulting angle for a 6 mm high rib lies between 15° and 22° (evaporators with a 6 mm high rib also already exhibit a significantly better drainage and storage behavior than evaporators with an 8 mm high rib, although the number of drainage surfaces and flat pipes is already greater here). The water separation is favored even further by the presence of a larger available drainage area along the flat pipes and by the larger number of drainage surfaces/flat pipes for a comparable quantity of condensate.